2.12 DETAILED RESULTS FOR CLUTTER

The Clutter Functional Element (FE) is not implemented as specified in Section 2.12 of ASP-II, but the discrepancies found can be corrected by minor code adjustments. The quality of the code implementing the FE is good. Internal code documentation for the FE is good, with a minor exception. External documentation is incomplete, but the quality of documentation for the included topics is good.

The table below summarizes the desk-checking and software testing verification results for each design element in the Clutter FE. One entry is listed for each design element. The results columns contain check marks if no discrepancies were found during verification. Where discrepancies were found, the Desk Check Result column contains References (D1, D2) to discrepancies listed in Table 2.12-4, while the Test Case Result column identifies the relevant test cases which explain the discrepancies listed in Table 2.12-6.

TABLE 2.12-1. Verification Results Summary for Clutter FE.

Design Element	**Code Location**	**Desk Check Result**	**Test Case ID**	**Test Case Result**
12-1: Clutter Patch Area for a Pulse-Length-Limited Case	CLUTG 291-294	D1 D2	12-3	12-3
12-2: Clutter Patch Area for a Beamwidth-Limited Case	CLUTG 287-290	D3 D4	12-4	12-4
12-3: Depression Angle	CLUTG 175-180	√	12-5	√
12-4: Grazing Angle	CLUTG 212-218	√	12-6	√
12-5: Radar Horizon	CLUTG 168	√	12-7	√
12-6: Backscatter From Land	CLUTG 97-166, 223-225	√	12-8	√
12-7: Backscatter From Sea	CLUTG 95,96, 226-286	√	12-9 through 12-12	√
12-8: User-Defined Reflectivity	CLUTG 299-304	√	12-13	√
12-9: Clutter Power	CLUTG 169,171, 202, 296-298, 307-316	√	12-14 12-15	12-14 12-15
Utility Function, arccos function with error check	ACOSC	√	12-16	√
User Input	INPUT1, INPUT2	√	all	√
System Parameters	RDRDAT	√	all	√

2.12.1 Overview

Clutter may be defined as the signal return from unintended targets; the most significant clutter signals are due to reflections from the earth's surface. The intensity of the clutter echo is calculated using the standard radar equation, with target cross section replaced by the effective radar cross section of the illuminated clutter object. The effective radar cross section of the clutter patch (s_0) is the product of the ground area illuminated by the radar and the reflection coefficient of the earth's surface. *RADGUNS* approximates the clutter patch area using the area of a (plane) ellipse or rectangle; it uses reflection coefficients from Reference 4.

RADGUNS implements the FE primarily in Subroutine CLUTG. Subroutines ACOSC, ANTTRK, and RANDOM support CLUTG calculations; the support modules are used by other FEs in addition to the Clutter FE. These and other subroutines used for this FE are briefly described in Table 2.12-2.

TABLE 2.12-2. Subroutine Descriptions.

Module Name	**Description**
AAASIM	Main routine which simulates AAA system
ACOSC	Calculates inverse cosine function with error check
ANTTRK	Calculates antenna gain scaling factor for off-boresight angle of the clutter patch
CLUTG	Computes power returned from ground clutter patch
ENGAGE	Simulates tracking mode of radar operation
INPUT1, INPUT2	Reads (from data file) and initializes user input
PERCUE	Simulates search for target with antenna perfectly cued to target position
RANDOM	Computes a random number in the range [-1,1]
RDRDAT	Initializes system-specific variables
SIGNL	Calculates power at the radar receiver due to return signals from the target and clutter
SRCH1, SRCH2	Simulates search for target for sector and circular antenna search patterns

2.12.2 Design Elements

The Clutter FE contains nine design elements. A design element is an algorithm that represents a specific component of the FE design. These elements are specified in the Design Approach section of the ASP-II for *RADGUNS*. The design elements for the FE are listed in Table 2.12-3.

TABLE 2.12-3. Clutter Design Elements.

Module	**Design Element**	**Description**
CLUTG	12-1: Clutter Patch Area for a Pulse-Length Limited Case	Calculates clutter patch area for a pulse-length limited case.
CLUTG	12-2: Clutter Patch Area for a Beam Width Limited Case	Calculates clutter patch area for a beamwidth-limited case.
CLUTG	12-3: Depression Angle	Calculates the depression angle (also called the elevation angle) of the ground clutter patch with respect to the radar antenna.

TABLE 2.12-3. Clutter Design Elements. (Contd.)

Module	Design Element	Description
CLUTG	12-4: Grazing Angle	Calculates the transmit beam angle with respect to the local horizontal plane of the clutter patch.
CLUTG	12-5: Radar Horizon	Calculates the slant range to horizon from the radar antenna.
CLUTG	12-6: Backscatter From Land	Calculates the backscatter coefficient for a land environment.
CLUTG	12-7: Backscatter From Sea	Calculates the backscatter coefficient for a sea environment.
CLUTG and RANDOM	12-8: User-Defined Reflectivity	Adds a random variation to a user-defined backscatter coefficient.
CLUTG	12-9: Clutter Power	Calculates the power at the receiver from clutter return signals.
ACOSC	Utility	Calculates the inverse cosine after checking for round-off errors.
INPUT1, INPUT2	Input	Reads and initializes user input.
RDRDAT	Input	Initializes radar parameters.

2.12.3 Desk Check Activities and Results

The code implementing this FE was manually examined using the procedures described in Section 1.1 of this report. Discrepancies found by desk-checking are described in Table 2.12-4. Internal documentation and code quality problems are described in Table 2.12-5.

TABLE 2.12-4. Desk-Checking Discrepancies.

Design Element	Desk Check Result
12-1: Clutter Patch Area, Pulse-Length- Limited Case	D1. For the “Descriptive Model,” the pulse width is divided by 2 in the coded equation for variable AREA, which implements the clutter patch area (ASP-II Equation [2.12-1]). The division by two should not be in the equation. D2. For the “Numerical Model,” a small-angle approximation of ASP-II equation [2.12-2] is used to calculate the clutter patch area; the area calculations are included in calculation of clutter patch RCS (variable SIGMAC). For the clutter patch area portion of RCS calculation, a factor of 0.75 is missing as a multiplier to the half-power azimuth beamwidth; thus, the three-fourths conventional 3-dB one-way beamwidth of the antenna pattern qualifier cited by Blake (Reference 5) is not implemented in code.
12-2: Clutter Patch Area, Beamwidth Limited Case	D3. For the “Descriptive Model,” a multiplicative factor of four is in the denominator of the coded equation defining variable AREA, which implements the clutter patch area (ASP-II Equation [2.12-6]). The factor of four should not be in the equation. D4. For the “Numerical Model”, no beamwidth-limited clutter patch area calculation is implemented in code; the pulse-length-limited algorithm is used to calculate the area for <u>all</u> grazing angles (although it is not implemented correctly (see D2 above)). Thus, the same clutter patch-radar-target scenario generally will not yield duplicate clutter patch areas in “Numerical” and “Descriptive” models for a beamwidth-limited case.

TABLE 2.12-5. Code Quality and Internal Documentation Discrepancies.

Module	Code Quality	Internal Documentation
CLUTG	The first IF-THEN block initializes variables that remain constant throughout the entire simulation run. Variable FACTOR is a constant that should be included in the block, but is not. Variables SIGH and SIGV are the horizontal and vertical components of diffuse backscatter from a sea environment. Both are calculated, but only one is used, so the other calculation is unnecessary. For the “Descriptive Model,” variable SIGMA0 stores the surface backscatter coefficient for the current grazing angle. However, the “Numerical Model” stores the backscatter coefficient only at normal incidence (not accounting for grazing angle); the grazing angle is included at a later calculation. Thus, the data stored in SIGMA0 for the two “models” do not represent the same physical quantity. For the pulse-length-limited case, clutter patch area calculation utilizes small angle approximations in the “Numerical Model”; the “Descriptive Model” does not utilize the approximations. Thus, the same radar-target-clutter patch scenario generally will not yield duplicate clutter patch areas for both “Numerical” and “Descriptive” Models in the pulse-length-limited case.	Some variables are not defined at the beginning of the subroutine. The formatted header does not describe the processes modeled in the subroutine.

2.12.4 Software Test Cases and Results

Software testing for Subroutine CLUTG was performed by running the entire *RADGUNS* model. For these tests, *RADGUNS* was run using the subject AAA system, A10A as the target, and EX2.PAR as the parameters file. EX2 was supplied with the *RADGUNS* code. In most cases these files were used as delivered. The EX2.PAR file was modified to change the flight path X-position to 5000 instead of 30000; this modification results in a target flight path residing within the distance to the horizon, which is a requirement for inclusion of clutter simulation. The Digital Command Language (DCL) file RUNRG.COM was modified to run *RADGUNS* in VAX debug mode. Any other file modifications are listed in the test descriptions. A driver was written to exercise Subroutine ACOSC. Subroutine RANDOM is included in the Multipath FE (FE 13), and was not tested during the Clutter FE verification. Similarly, Subroutine ANTTRK is included in the Antenna Gain FE (FE 20). Table 2.12-6 presents the software test cases for the Clutter FE. The subject module for the tests is CLUTG, unless indicated otherwise.

TABLE 2.12-6. Software Test Cases for the Clutter FE.

Test Case ID	Test Case Description
12-1	OBJECTIVE: Verify that general constants, initial geometry data, and system input data for the Clutter FE are correctly initialized. PROCEDURE: 1. Execute *RADGUNS*, and observe the initialization of BMAZ, BMEL, C, ELBW, GANT, HANT, PHIB, PHICRT, PI, POLRZ, PTX, PW, RANGE, RE, TOTLOS, TWOPI, and WLNTH. 2. Enter “NUME” at item #20 [1], “0.0, 2000.0" at item #20 [3] of the user input file. 3. Re-run *RADGUNS*, and observe the value of CLUTON before execution of line 300. 4. Observe the execution path after line 301. 5. Observe the value of CLUTG. VERIFY: 1. Initialization of BMAZ, BMEL, and RANGE match those of the calling routine. 2. Initialization of C, PI, RE, and TWOPI match those of Subroutine GENDAT. 3. Initialization of ELBW, GANT, HANT, PHIB, PHICRT, POLRZ, PTX, PW, TOTLOS, AND WLNTH match those of Subroutine RDRDAT. 4. The value of CLUTON observed in Step 3 equals “FALSE.” 5. Execution transfers to line 311 (which bypasses clutter calculations). 6. The value of CLUTG observed in Step 5 equals zero. RESULT: OK
12-2	OBJECTIVE: Verify correct initialization of user-defined data, and land form and cover backscatter coefficients. PROCEDURE: 1. Execute *RADGUNS*, and observe the initialization of CLUTYP, TERAIN, LNDFRM, and LNDCVR. 2. Observe the initialization of diffuse backscatter coefficients in array variable CLAND (x,y,2), where x = 1 through 6, and y = 1 through 5. 3. Observe the initialization of quasi-specular backscatter coefficients in array variable CLAND (x,y,1), where x = 1 through 6, and y = 1 through 5. 4. Observe the same array entries of CLAND in Step 1 and 2 after conversion from dB to absolute at lines 159 through 166. VERIFY: 1. The initializations observed in Step 1 are CLUTYP = DESC, TERAIN = LAND, LNDFRM = 3, and LNDCVR = 2. 2. The initializations observed in Step 2 match the values of ASP-II Table 2.12-1. 3. The initializations observed in Step 3 match the values of ASP-II Table 2.12-2. 4. Correct conversion from dB to absolute occurs in Step 4. RESULT: OK

TABLE 2.12-6. Software Test Cases for the Clutter FE. (Contd.)

Test Case ID	Test Case Description
12-3	OBJECTIVE: Test Design Element 12-1: Clutter Patch Area for a Pulse-Length- Limited Case; confirm discrepancy D1. PROCEDURE: 1. Run *RADGUNS*, and observe the value of RANGE. 2. Observe the value of variable PSI1. 3. Freeze execution after calculation of variable PSI, and deposit a value into PSI that is less than PSI1. 4. Observe the execution path to variable AREA after line 287. 5. Observe the value of AREA. VERIFY: 1. Value of PSI1 matches independent calculation of the conditional portion of ASP-II Equation [2.12-1]. 2. Execution path transfers to line 293 in Step 4. 3. Value of AREA matches independent calculation of A_c in ASP-II Equation [2.12-1] using the values of constants observed in Test 12-1 and the value of PSI from Step 3. RESULT: Independent calculation of A_c in ASP-II Equation [2.12-1] did not match the simulation value of AREA, confirming discrepancy D1 found during desk-checking.
12-4	OBJECTIVE: Test Design Element 12-2: Clutter Patch Area for a Beamwidth-Limited Case; confirm discrepancy D3. PROCEDURE: 1. Run *RADGUNS*, and observe the value of RANGE. 2. Observe the value of variable PSI1. 3. Freeze execution after calculation of variable PSI, and deposit a value into PSI that is greater than PSI1. 4. Observe the execution path to variable AREA after line 287. 5. Observe the value of AREA. VERIFY: 1. Execution path transfers to line 289 in Step 4. 2. Value of AREA matches independent calculation of A_c in ASP-II Equation [2.12-6] using the values of constants observed in Test 12-1 and the value of PSI from Step 3. RESULT: Independent calculation of A_c in ASP-II Equation [2.12-6] did not match the simulation value of AREA, confirming discrepancy D3 found during desk-checking.

TABLE 2.12-6. Software Test Cases for the Clutter FE. (Contd.)

Test Case ID	Test Case Description
12-5	OBJECTIVE: Test Design Element 12-3: Depression Angle. PROCEDURE: 1. Execute *RADGUNS*, and observe the initialization of variables HANT and RANGE 2. Observe the execution path to variable CLEL after line 175. 3. Observe the value of CLEL. 4. Repeat Step 1. 5. Deposit a value into RANGE that is less than the value of HANT. 6. Repeat Steps 2 and 3. VERIFY: 1. The value of RANGE observed in Step 1 is greater than that of HANT. 2. Execution path transfers to line 176 in Step 2. 3. The value of CLEL observed in Step 3 matches independent calculation of ASP-II Equation [2.12-9]. 4. Execution path transfers to line 179 in Step 6. 5. The value of CLEL observed in Step 6 equals $\pi/2$. RESULT: OK
12-6	OBJECTIVE: Test Design Element 12-4: Grazing Angle. PROCEDURE: 1. Execute *RADGUNS*, and observe the initialization of variables HANT and RANGE. 2. Observe the execution path to variable PSI after line 212. 3. Observe the value of PSI. 4. Repeat Step 1. 5. Deposit a value into RANGE that is less than the value of HANT. 6. Repeat Steps 2 and 3. 7. Re-run *RADGUNS*, and freeze execution after calculation of PSI at line 214. 8. Deposit a value of 1.0E-11 into PSI. 9. Execute another line of code. 10. Observe the value of PSI. VERIFY: 1. The value of RANGE observed in Step 1 is greater than that of HANT. 2. Execution path transfers to line 213 in Step 2. 3. The value of PSI observed in Step 3 matches independent calculation of ASP-II Equation [2.12-13]. 4. Execution transfers to line 217 in Step 6. 5. The value of PSI observed in Step 6 equals $\pi/2$. 6. The value of PSI observed in Step 10 equals 1.0E RESULT: OK

TABLE 2.12-6. Software Test Cases for the Clutter FE. (Contd.)

Test Case ID	Test Case Description
12-7	OBJECTIVE: Test Design Element 12-5: Radar Horizon. PROCEDURE: 1. Execute *RADGUNS*, and observe the initialization of variables HANT and RE. 2. Observe the value of RHORIZ at line 168. VERIFY: The value of RHORIZ observed in Step 2 matches independent calculation of ASP-II Equation [2.12-15]. RESULT: OK
12-8	OBJECTIVE: Test Design Element 12-6: Backscatter from Land. PROCEDURE: 1. Run *RADGUNS*, and observe the initialization of variables PHICRT, LNDCVR, and LNDFRM. 2. Observe the value of variable PSI before line 221. 3. Observe the value of variable PHI at line 221. 4. Deposit a value into PHI that is greater than that of PHICRT. 5. Observe the value PHI after execution of line 223. 6. Observe the value of variables CLAND(LNDCVR,LNDFRM,1) and CLAND(LNDCVR,LNDFRM,2) in the calculation of variable SIGMA at line 224. 7. Observe the value of SIGMA at line 224. VERIFY: 1. Value of PHI observed in Step 3 matches independent calculation of f in ASP-II Equation [2.12-16]. 2. The value of PHI observed in Step 5 equals the value of PHICRT observed in Step 1. 3. The value of SIGMA observed in Step 7 equals independent calculation of ASP-II Equation [2.12-16]. RESULT: OK

TABLE 2.12-6. Software Test Cases for the Clutter FE. (Contd.)

Test Case ID	Test Case Description
12-9	OBJECTIVE: Test Design Element 12-7: Backscatter from Sea, Diffuse Horizontal Polarization Component. PROCEDURE: 1. Enter "SEA" for the environment, "5" for the sea state, and "45" for the wind aspect angle in the user input file. 2. Run *RADGUNS*, and observe the initialization of variables TERAIN, ISEAST, and WNDASP. 3. Observe the value of PSI and SIGZ at line 228 and SIGPHI at line 229. 4. Observe the value of GA at line 231. 5. Observe the value of VW at line 233. 6. Observe the value of QTRM, A4TRM, A3TRM, A2TRM, A1TRM, and ATRM at lines 233, 234, 235, 236, 237, and 238, respectively. 7. Observe the value of GW and GU at lines 239 and 245, respectively. 8. Observe the value of SIGH at line 248, and the value of SIGSED before execution of line 264. 9. Re-run *RADGUNS* with the same inputs as in Step 1, except use "90" for the wind aspect angle in the user input file. 10. Observe the execution path to GU after line 241, and note the value of GU. VERIFY: 1. The initializations of TERAIN = SEA, ISEAST = 5, and WNDASP = $\pi/_4$ occur in Step 2. 2. The value of SIGZ observed in Step 3 matches independent calculation of σ_z in ASP-II Equation [2.12-29] using the observed value of PSI. 3. The value of SIGPHI observed in Step 3 matches independent calculation of σ_φ in ASP-II Equation [2.12-28]. 4. The value of GA observed in Step 4 matches independent calculation of G_A in ASP-II Equation [2.12-27]. 5. The value of VW observed in Step 5 matches independent calculation of V_W in ASP-II Equation [2.12-20]. 6. The value of QTRM observed in Step 6 matches independent calculation of Q in ASP-II Equation [2.12-26]. 7. The value of A4TRM observed in Step 6 matches independent calculation of A_4 in ASP-II Equation [2.12-25]. 8. The value of A3TRM observed in Step 6 matches independent calculation of A_3 in ASP-II Equation [2.12-24]. 9. The value of A2TRM observed in Step 6 matches independent calculation of A_2 in ASP-II Equation [2.12-23]. 10. The value of A1TRM observed in Step 6 matches independent calculation of A_1 in ASP-II Equation [2.12-22]. 11. The value of ATRM observed in Step 6 matches independent calculation of A in ASP-II Equation [2.12-21]. 12. The value of GW observed in Step 7 matches independent calculation of G_W in ASP-II Equation [2.12-19].

TABLE 2.12-6. Software Test Cases for the Clutter FE. (Contd.)

Test Case ID	**Test Case Description**
12-9 (Contd.)	13. The value of GU observed in Step 7 matches independent calculation of the exponential equation for G_u in ASP-II Equation [2.12-18]. 14. The value of SIGH and SIGSED observed in Step 8 matches independent calculation of σ_H in ASP-II Equation [2.12-17]. 15. Execution transfers to line 243 in Step 9, where GU is set equal to one. RESULT: OK
12-10	OBJECTIVE: Test Design Element 12-7: Backscatter from Sea, Diffuse Vertical Polarization Component. PROCEDURE: 1. Enter “SEA” for the environment, “5” for the sea state, and “45” for the wind aspect angle in the user input file. 2. Run *RADGUNS*, and observe the initialization of WLNTH. 3. Observe the value of PSI and SIGZ at line 228 and SIGH at line 248. 4. Deposit a value into WLNTH that is greater than 0.15 before execution of the next line of code. 5. Observe the execution path to SIGV, and note the value of SIGV. 6. Repeat Steps 1 through 3. 7. Deposit a value into WLNTH that is less than 0.15 before execution of the next line of code. 8. Observe the execution path to SIGV, and note the value of SIGV. 9. Before execution of another line of code, deposit a value of “V” into POLRZ. 10. Observe the value of SIGSED before execution of line 264. VERIFY: 1. Execution transfers to line 251 in Step 5. 2. The value of SIGV observed in Step 5 matches independent calculation of σ_v for $f < 2000$ MHZ in ASP-II Equation [2.12-30]. 3. Execution transfers to line 255 in Step 8. 4. The value of SIGV observed in Step 8 matches independent calculation of σ_v for f 5. The value of SIGSED observed in Step 10 equals that of SIGV from Step 8. RESULT: OK

TABLE 2.12-6. Software Test Cases for the Clutter FE. (Contd.)

Test Case ID	Test Case Description
12-11	OBJECTIVE: Test Design Element 12-7: Backscatter from Sea, Quasi-Specular Component, transmit wavelength < 0.05 m, sea state > 2, grazing angle PROCEDURE: 1. Enter "SEA" for the environment, "5" for the sea state, and "45" for the wind aspect angle in the user input file. 2. Run *RADGUNS*. 3. Deposit a value less than 0.05 into WLNTH before execution of line 264. 4. Observe the execution path to AMU after line 264, and note the value of AMU. 5. Observe the execution path to B0 after line 269, and note the value of B0. 6. Deposit a value into PSI that is greater than 0.001 before execution of line 274. 7. Observe the execution path to EXPO after line 274, and note the value of EXPO. 8. Deposit a value greater than -70.0 into EXPO before execution of another line. 9. Observe the execution path to EXPO after line 278; note the new value of EXPO. 10. Observe the value of SIGSES. VERIFY: 1. Execution transfers to line 265 in Step 4. 2. Value of AMU observed in Step 4 matches independent calculation of μ in ASP-II Equation [2.12-31] for the case $\lambda < 0.05$m. 3. Execution transfers to line 272 in Step 5. 4. Value of B0 observed in Step 5 matches independent calculation of β_0 in ASP-II Equation [2.12-32] for the case s > 2. 5. Execution transfers to line 277 in Step 7. 6. Value of EXPO observed in Step 7 matches independent calculation of the exponent in ASP-II Equation [2.12-33]. 7. Execution transfers to line 281 in Step 9. 8. Value of EXPO observed in Step 9 matches independent calculation of the exponential expression in ASP-II Equation [2.12-33]. 9. Value of SIGSES observed in Step 10 matches independent calculation of σ^o_s in ASP-II Equation [2.12-33]. RESULT: OK

TABLE 2.12-6. Software Test Cases for the Clutter FE. (Contd.)

Test Case ID	Test Case Description
12-12	OBJECTIVE: Test Design Element 12-7: Backscatter from Sea, Quasi-Specular Component, transmit wavelength PROCEDURE: 1. Repeat Steps 1 and 2 of Test Case 12-11. 2. Deposit a value greater than 0.05 into WLNTH, a value of 2 into ISEAST, and a value less than 0.001 into PSI before execution of line 264. 3. Observe the execution path to AMU after line 264, and note the value of AMU. 4. Observe the execution path to B0 after line 269, and note the value of B0. 5. Observe the execution path to EXPO after line 274, and note the value of EXPO. 6. Repeat steps 1 through 5, except deposit a value greater than .001 into PSI. 7. Deposit a value into EXPO that is less than -70.0 before execution of another line. 8. Observe the execution path to EXPO after line 278; note the new value of EXPO. VERIFY: 1. Execution transfers to line 267 in Step 3. 2. Value of AMU observed in Step 3 matches independent calculation of m in ASP-II Equation [2.12-31] for the case l 3. Execution transfers to line 270 in Step 4. 4. Value of B0 observed in Step 4 matches independent calculation of b_0 in ASP-II Equation [2.12-32] for the case s 5. Execution transfers to line 275 in Step 5. 6. Value of EXPO observed in Step 5 equals zero. 7. Execution transfers to line 279 in Step 8. 8. Value of EXPO observed in Step 8 equals zero. RESULT: OK
12-13	OBJECTIVE: Test Design Element 12-8: User-Defined Reflectivity. PROCEDURE: 1. Enter "NUME" at item #20 [1], "0.75, 0.1" at item #20 [2], and "0.5, 0.5, 20.0, 2000.0" at item #20 [3] of the user input file. 2. Run *RADGUNS*, and observe the initialization of user-defined variables CLUTYP, CLUPAR(1), and CLUPAR(2). 3. Observe the value of SIGMA at line 304. 4. Observe the value of SIGMA0 at line 306. VERIFY: 1. The values of CLUTYP, CLUPAR(1), and CLUPAR(2) observed in Step 2 equal "NUME," 0.75, and 0.1, respectively. 2. The value of SIGMA observed in Step 3 matches independent calculation of σ^0 in ASP-II Equation [2.12-35]. 3. Conversion from SIGMA in decibels to absolute SIGMA0 occurs in Step 4. RESULT: OK

TABLE 2.12-6. Software Test Cases for the Clutter FE. (Contd.)

Test Case ID	**Test Case Description**
12-14	OBJECTIVE: Test Design Element 12-9: Clutter Power, Clutter Patch RCS; confirm discrepancy D2. PROCEDURE: 1. Run *RADGUNS*, and observe the value of AREA and SIGMA0 before execution of line 296. 2. Observe the value of SIGMAC at line 296. 3. Enter “NUME” at item #20 [1], and “0.75, 0.1" at item #20 [2] of the user input file. 4. Re-run *RADGUNS*, and freeze execution immediately following calculation of SIGMA0 at line 306. 5. Deposit a value into SIGMA0 equal to the value of SIGMA0 observed in Step 1. 6. Execute line 307, and note the value of SIGMAC. VERIFY: 1. The value of SIGMAC observed in Step 2 matches independent calculation of ASP-II Equation [2.12-36]. 2. The value of SIGMAC observed in Step 6 equals that of SIGMAC observed in Step 2. RESULT: The value of SIGMAC observed in Step 6 did <u>not</u> equal that of SIGMAC observed in Step 2. The difference was due to an apparent discrepancy in the calculation of clutter patch area in Step 6; thus discrepancy D2 (found during desk-checking) was confirmed.
12-15	OBJECTIVE: Test Design Element 12-9: Clutter Power. PROCEDURE: 1. Run *RADGUNS*. 2. Observe the value of FACTOR, ANTENA, and SIGMAC before calculation of CLUTG at line 298. 3. Observe the value of CLUTG at line 298. 4. Enter “NUME” at item #20 [1], and “0.75, 0.1" at item #20 [2] of the user input file. 5. Re-run *RADGUNS*, and observe the value of FACTOR, ANTENA, and SIGMAC before calculation of CLUTG at line 309. 6. Observe the value of CLUTG at line 309. VERIFY: 1. The value of CLUTG observed in Step 3 matches independent calculation of P_c in ASP-II Equation [2.12-37]. 2. The value of CLUTG observed in Step 6 matches independent calculation of P_c in ASP-II Equation [2.12-37]. RESULT: OK

TABLE 2.12-6. Software Test Cases for the Clutter FE. (Contd.)

Test Case ID	Test Case Description
12-16	OBJECTIVE: Test ACOSC, the inverse cosine function with error check. PROCEDURE: 1. Develop a driver with a recursive loop which inputs the following values of X into Subroutine ACOSC(X): -1.00011, -1.00010, -1.000099, 1.00011, 1.00010, 1.000099. 2. Execute the driver, and for each of the six inputs in Step 1, observe its initialization in Subroutine ACOSC. 3. Observe the value of variable Y before the calculation of ACOSC for each pass through the recursive loop. VERIFY: 1. Initializations in Step 2 match the input values from Step 1. 2. The following values of Y are observed in Step 3: -1.00011, -1.00010, -1.00000, 1.00011, 1.00010, 1.0000. RESULT: OK

2.12.5 Conclusions and Recommendations

2.12.5.1 Code Discrepancies

Verification activities revealed discrepancies in *RADGUNS* v.1.8 implementation of the Clutter Functional Element. Conclusions and recommendations that follow are referenced to desk-checking notes from Table 2.12-4 (designated by D1, D2, …), and to software test case numbers (12-1, 12-2,...) from Table 2.12-6. All discrepancies in this portion describe problems in Subroutine CLUTG.

D1 and Test Case 12-3. A factor of two is in the denominator of the equation defining variable AREA. The factor should not be in the equation. AREA should implement ASP-II Equation [2.12-1].

D2 and Test Case 12-14. The missing multiplicative factor of 0.75 should be added to clutter patch area calculations (embedded in the calculation of variable SIGMAC) for the “Numerical Model”; the surface area calculation should implement ASP-II Equation [2.12-2].

D3 and Test Case 12-4. A factor of four is in the denominator of the equation defining variable AREA. The factor should not be in the equation. AREA should implement ASP-II Equation [2.12-6].

D4. An execution path to beamwidth-limited clutter area calculations should be available to the “Numerical Model.” The recommended process is to calculate the clutter patch area before execution of procedures specialized to either the descriptive clutter model or the numerical clutter model. Specifically, after determining that the clutter patch area resides within the horizon distance, the next step should be calculation of clutter patch area; this area then should be used to calculate RCS for both clutter models.

2.12.5.2 Code Quality and Internal Documentation

Comprehensive variable initialization should be incorporated in future releases. Description of all global variables also should be added.

Variable FACTOR should be moved to the first IF-THEN block (which initializes variables that remain constant throughout the entire simulation run).

Variables SIGH and SIGV are the horizontal and vertical components of backscatter for a sea state. Radar systems modeled in file RAD1.FOR are polarized either horizontally or vertically, and thus a polarization check (IF-THEN block) should be added to force either calculation of SIGH or SIGV, but not both of them.

For the “Numerical Model,” the grazing angle factor (variable GRZFAC) should be multiplied by the backscatter coefficient at normal incidence (variable SIGMA) to calculate the backscatter coefficient corresponding to the current grazing angle (variable SIGMA0); this will result in a common definition for variable SIGMA0 for both clutter “models.”

The “Numerical Model” utilizes the small angle approximation defined by ASP-II Equation [2.12-2] to calculate clutter patch area for all incidence angles. Small angle approximations are <u>not</u> used by the “Descriptive Model.” Consistency of simulation methods for the two “models” should be achieved by using a common equation to describe the clutter patch area for identical scenario geometries. Small-angle approximations should be used to gain computational efficiency. Thus, ASP-II Equations [2.12-2] and [2.12-7] are recommended for clutter patch surface area calculation.

2.12.5.3 External Documentation

The external documentation is good for the subjects discussed in the combined User/Analyst/ Programmer Manual. However, the manual is incomplete in the subject areas discussed in the paragraphs which follow. Also, documentation errors are noted.

The combined manual has analyst’s information included in appendices that present theoretical descriptions of several modeled processes. Design approach information related to the “Numerical Model” portion of the Clutter FE is in Appendix VI. This portion incorporates discussion of the low grazing angle scenario (pulse-length-limited case) discussed in ASP-II Design Element 12-1. The beamwidth-limited scenario described is not described; the manual should include the design information presented in ASP-II Design Element 12-2. Also, Appendix VI refers to equation numbers in its discussion, but equations are <u>not</u> numbered in the appendix; the equations should be numbered, and the text should be checked for reference accuracy.

An important design aspect related to the Clutter FE is the “descriptive clutter model,” which calculates reflectivity based on empirical data; this design aspect is not described in Appendix VI. Thus, a description should be added which incorporates the design approach described in ASP-II Design Elements 12-6 and 12-7. Also, the equation (in the appendix) for power returned from the ground clutter patch is missing the Pattern Propagation Factor. The equation for clutter power should be changed to that of ASP-II Design Element 12-9, Equation [2.12-37].

The programmer's manual information is documented in the form of module descriptions in Section V. Subroutine CLUTG is the key subroutine for the FE. An error in Item #2 (Calling Sequence) is the inclusion of a fourth argument, NRADAR; only three arguments are implemented. An error in Item #6 (Calling Environment) is the specification that Subroutine SQR is called by CLUTG; no such call is made. Item #8 (Discussion and Formulation) has detailed methodology descriptions which should be reserved for analyst's manual information. In fact, Item #8 has information already included in Appendix VI, except for the first paragraph. Therefore, Item #8 should be deleted, except for the first paragraph, which should be moved to Appendix VI. Item #1, Brief Description, presents a short explanation of the subroutine tasks; a sentence should be added to refer the reader to Appendix VI for more detailed information.

An error in Item #8 is the specification that variable CLUTG is the elevation angle of the ground clutter patch; the correct variable name is CLEL. Variable CLUTG is the value of Function CLUTG, which is the clutter power.